

diesel engines applied in passenger cars and light-heavy trucks. Acceptance of the technology by the public, especially in Europe, has led to a rapid increase in diesel use for smaller vehicles with diesel sales for passenger cars exceeding 50 percent in some countries.

At the end of the 1990s continuing concern regarding the serious risk to public health and welfare from diesel emissions and the emergence of new emission control technologies enabled by low sulfur fuels led policy makers to set new future diesel fuel specifications and to set challenging new diesel emission standards for highway vehicles. In the United States, the EPA has set stringent new diesel emission standards for heavy-duty highway engines which will go into effect in 2007. These new standards are predicated on the use of Catalyzed Diesel Particulate Filters (CDPFs) which when used with less than 15ppm sulfur diesel fuel can reduce PM emissions by well over 90%, and on the use of NO_x adsorber catalyst technology which when used with less than 15 ppm diesel fuel can reduce NO_x emissions by more than 90%. When these technologies are fully implemented, the resulting diesel engine emissions will be 98% lower than the levels common to these diesel engines before 1990.

EPA has been conducting an ongoing technology progress review to measure industry progress to develop and introduce the needed clean fuel and clean engine technologies by 2007. The first in what will be a series of reports was published by EPA in June of 2002.¹²⁸ In the report, we concluded that technology developments by industry were progressing rapidly and that the necessary catalyzed diesel particulate filter and NO_x adsorber technologies would be available for use by 2007.

Nonroad diesel engines are fundamentally similar to highway diesel engines. As noted above in section III.B, in many cases, virtually identical engines are certified and sold for use in highway vehicles and nonroad equipment. Thus, emission control technologies developed for diesel engines can in general be applied to both highway and nonroad engines giving appropriate considerations to unique aspects of each application.

Today, we are proposing to set stringent new standards for a broad category of nonroad diesel engines. At the same time we are proposing to

dramatically lower the sulfur level in nonroad diesel fuel ultimately to 15 ppm. We believe these standards are feasible given the availability of the clean 15 ppm sulfur fuel and the rapid progress to develop the needed emission control technologies. We acknowledge that these standards will be challenging for industry to meet in part due to differences in operating conditions and duty cycles for nonroad diesel engines. Also, we recognize that transferring and effectively applying these technologies, which have largely been developed for highway engines, will require additional lead time. We have given consideration to these issues in determining the appropriate timing and emission levels for the standards proposed today.

The following sections will discuss how these technologies work, issues specific to the application of these technologies to new nonroad engines, and why we believe that the emission standards proposed here are feasible. A more in-depth discussion of these technologies can be found in the draft RIA associated with this proposal, in the final RIA for the HD2007 emission standards and in the recently completed 2002 Highway Diesel Progress Review.¹²⁹ The following discussion summarizes the more detailed discussion found in the Draft RIA.

1. Technologies To Control NO_x and PM Emissions From Mobile Source Diesel Engines

Present mobile source rules control the emissions of non-methane hydrocarbons (NMHC), oxides of nitrogen (NO_x), carbon monoxide (CO), air toxics and particulate matter (PM) from diesel engines. Of these, PM and NO_x emissions are typically the most difficult to control. CO and NMHC emissions are inherently low from diesel engines and under most conditions can be controlled to low levels without difficulty. NMHC emissions also serve as a proxy for some of the air toxic emissions from these engines, since many air toxics are a component of NMHC and are typically reduced in proportion to NMHC reductions. Most diesel engine emission control technologies are designed to reduce PM and NO_x emissions without increasing CO and NMHC emissions above the already low diesel levels. Technologies to control PM and NO_x emissions are described below separately. We also discuss the potential for these technologies to decrease CO

and NMHC emissions as well as their potential to reduce emissions of air toxics.

a. PM Control Technologies

Particulate matter from diesel engines is made of three components;

- Solid carbon soot,
- Volatile and semi-volatile organic matter, and
- Sulfate.

The formation of the solid carbon soot portion of PM is inherent in diesel engines due to the heterogeneous distribution of fuel and air in a diesel combustion system. Diesel combustion is designed to allow for overall lean (excess oxygen) combustion giving good efficiencies and low CO and HC emissions with a small region of rich (excess fuel) combustion within the fuel injection plume. It is within this excess fuel region of the combustion that PM is formed when high temperatures and a lack of oxygen cause the fuel to pyrolyze, forming soot. Much of the soot formed in the engine is burned during the combustion process as the soot is mixed with oxygen in the cylinder at high temperatures. Any soot that is not fully burned before the exhaust valve is opened will be emitted from the engine as diesel PM.

The soot portion of PM emissions can be reduced by increasing the availability of oxygen within the cylinder for soot oxidation during combustion. Oxygen can be made more available by either increasing the oxygen content in-cylinder or by increasing the mixing of the fuel and oxygen in-cylinder. A number of technologies exist that can influence oxygen content and in-cylinder mixing including, improved fuel injection systems, air management systems, and combustion system designs.¹³⁰ Many of these PM reducing technologies offer better control of combustion in general, and better utilization of fuel allowing for

¹³⁰ The most effective means to reduce the soot portion of diesel PM engine-out is to operate the diesel engine with a homogenous method of operation rather than the typical heterogeneous operation. In homogenous combustion, also called premixed combustion, the fuel is dispersed evenly with the air throughout the combustion system. This means there are no fuel rich/oxygen deprived regions of the system where fuel can be pyrolyzed rather than burned. Gasoline engines are typically premixed combustion engines. Homogenous combustion is possible with a diesel engine under certain circumstances, and is used in limited portions of engine operation by some engine manufacturers. Unfortunately, homogenous diesel combustion is not possible for most operation in today's diesel engine. We believe that more manufacturers will utilize this means to control diesel emissions within the limitations of the technology. A more in-depth discussion of homogenous diesel combustion can be found in the draft RIA.

¹²⁸ Highway Diesel Progress Review, United States Environmental Protection Agency, June 2002, EPA 420-R-02-016. Copy available in EPA Air Docket A-2001-28.

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